CELLULAR INTERNET PROTOCOL MODEM NETWORK

BACKGROUND OF THE INVENTION

Field of Invention

The present invention relates to cellular wireless data communications. In particular, the invention relates to cellular communications using a unique Protocol called Cellular IP as well as the network architecture for it.

Description of the Related Art

FIG. 1 shows an existing cellular data network 50. The Internet Service Provider (ISP) 55 or service provider in general provides the connectivity of Internet traffic for various user stations 50, 57 and 58. The base station 55 creates the cell 49, creating cellular service. That is, user stations 50, 57 and 58 are within cell 49 and are served by base station 55. The base station 55 connects the user stations 50 and 58 to the ISP 55 via a wireless link.

However, user station 66 may be outside the range of the base station 55, or may be within range but does not have line of sight because of obstruction by buildings such as station 57 obstructed by building 56. Therefore, user stations 57 and 66 cannot connect to the ISP 55.

A conventional solution is to build another base station or repeater to service user stations 57 and 66. However, this may involve significant expenditures in cost and equipment. There is a need for a more cost-effective way of providing service to user stations 57 and 66.

SUMMARY OF THE INVENTION

The present invention addresses these and other problems of the prior art by providing a Cellular Internet Protocol (CIP) system.

According to one embodiment, an apparatus according to the present invention is a cellular IP modem that includes a baseband-to-intermediate frequency unit and a radio frequency unit. The baseband-to-intermediate frequency unit is configured to have a routing engine based on Cellular Internet Protocol.

According to another embodiment, a method according to the present invention includes the steps of sending a data packet including routing information indicating an intermediate recipient other than a base station; receiving the packet at the intermediate

recipient; and sending the packet in accordance with the routing information from the intermediate recipient to the base station.

According to another embodiment, a network architecture is described to support the creation of the Cellular IP network and its elements.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of an existing cellular network.

FIG. 2 is a block diagram of a Cellular IP packet according to the present invention.

FIG. MM-1 is a block diagram of the new Cellular IP network and its elements.

FIG. MM-2 is a block diagram of a user station that does not have line of sight because of obstruction according to the present invention.

FIG. MM-3 is a block diagram of an end user setup.

FIG. MM-4 is a block diagram of the base station setup and elements.

FIG. MM-5 is a description of how the frequency planning is done with respect to time.

FIG. 3 is an embodiment of a frequency table used to generate a coded spectrum.

FIG. 4 is an embodiment of the bit stream modulation according to the present invention.

FIG. 5 is an embodiment of the RF section according to the present invention.

FIG. 6 is an embodiment of the demodulation according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 2 shows a frame format for a Cellular IP packet. The packet may be a variable-length packet with a maximum of 512 bytes. The packet may include a seven byte preamble, a one byte start-of-frame delimiter (SFD), a nine byte destination address (DA), a nine byte source address (SA), a 110 byte routing information block (RIB), a six byte type field, a six byte status field, a 360 byte data field and a four byte cyclic redundancy check (CRC) field.

The preamble contains alternating 1s and 0s for determination of a collision and establishing synchronization.

The SFD may have a value of <A5>h to indicate the beginning of the frame.

The DA may have one byte for indicating a region, such as the location within a country of the recipient user station. Eight bits give 256 (28) regions. Two bytes may be used to indicate the cell identifier within the region. Sixteen bits give 65,536 (216) cells. Six bytes indicate the Cellular IP address of the recipient user station within the cell.

The SA has fields similar to that of the DA but for indicating the sending user station instead of the recipient user station.

The RIB indicates the path that the packet should take from the ending user station to the base station. With a maximum of 110 bytes, the RIB can specify up to ten links in the route from the sending user station to the base station.

The frame type field indicates whether the packet is a control packet or a service packet. Specifically, their first two bytes indicate the protocol, the second two indicate the subprotocol, and the last two indicate the service. For example, if the first two bytes are <7777>h and the second two bytes are <0707>h, this indicates an "upgrade firmware" instruction with the third two bytes setting various flags. As another example, if the first two bytes are <0800>h, this indicates that the second two bytes will indicate "tcp/udp" and the third two bytes indicate the "service port number" (e.g., email is port 25, http is port 80 and ftp is port 20). Other subprotocols of Cellular IP include route discovery protocol, echo protocol and remote configuration protocol.

The status field may indicate information such as whether the packet is an ACK or a NACK packet, the number of data packets pending, spread spectrum synchronization information, or whether the packet is native or routed. The data field may include up to 360 bytes of data. The CRC field includes error detection or correction information.

<u>Routing Features</u>

FIG. MM-2 illustrates the routing features of a Cellular IP network 100. The ISP 102 provides the switching of Internet traffic for various user stations 104 and 106. Other base stations define cells 112 and 114, respectively, of cellular service. That is, user station 104 is cell 100 and is served by base station 102, and so on. The modems in cells 104 and 106 connect to the ISP 102.

User station labeled HOME A is outside of cell 100, either because it is out of range or because it is within range but obstructed by buildings such as 107 or any other obstruction. In such an event, user station HOME A uses a routing table to construct a RIB indicating a suitable communications link.

The routing table may be static or dynamic. In static routing, the routing table is defined when the Cellular IP modem is first installed. The user station 116 has a routing table containing information indicating that user station HOME A may connect to the modem in HOME B which has coverage from the base station 102, among any other routing information. A number of additional routes is possible for additional redundancy in case HOME B is out of service.

Network Architecture Features

The network architecture is slotted collision sensing multiple architecture with carrier detect (CSMA/CD) where the entire bandwidth is shared between all the users. The Cellular IP may be implemented in a spread spectrum with frequency hopping. For example, each cell may be configured to broadcast in 100 time slots (or equivalently, 100 frequency hops). That is, there are 100 transmission hops each second. Each user station and base station in the cell is configured with a starting hop number. The starting hop number is the number of the hop where any user modem can start transmitting packets until it is finished and while it is transmitting other users wait until it is finished even if it utilizes their hop slot. The advantage of this is since each modem starts at its own hop number, as long as no other modems are transmitting, it further reduces collisions between modems. For example, if the probability of collision in a CSMA/CD network where the modems can start transmitting at any random time is x and if this scheme of assigning a time reference "hop in this case" of 100 hops, this further reduces collisions by a factor of x/100. The hop number is either set at installation time or may be configured for each station via the ISP Base station.

This method minimizes collisions because each station listens to the current transmissions to determine if its starting hop number will be available. If it will be available, then the station begins a transmission on its starting hop number. If not, then the station waits. This reduces collisions because a collision only occurs when two conditions are met: (1) two stations have the same beginning hop number, and (2) both these stations want to transmit.

User Station Components

FIG. MM-3 shows the components of a user modem 150 and a computer 160. In a transmission mode, the computer 160 generates a packet of any protocol and the modem puts it in Cellular IP packets and the modem 150 transmits the packets. In a receiving mode, the modem 150 receives Cellular IP packets and strips of the Cellular IP information off of it and sends it to the computer 160 that processes the packets.

The modem 150 includes a radio frequency (RF) unit 154, antenna "indoor or outdoor" 155 and a baseband-to-intermediate frequency (BIF) unit 153. The RF unit 154 may be modular for inexpensive configuration for a desired operating frequency. Contemplated frequencies include MMDS at 2.6 GHz; LMDS at both 28 and 29 GHz; ISM at all three of 902-928 MHz, 2.4 GHz and 5.7 GHz; ITFS; MDS; and other private frequencies.

The BIF unit 158 converts the baseband information from the computer 160 into intermediate frequency information for processing by the RF unit 154. The link between the modem 150 and the computer 160 may be a serial cable, parallel cable, SCSI cable, Ethernet or universal serial bus cable.

Although the present invention has been described with reference to a "modem" and a "computer," with increasing miniaturization it is contemplated that similar principles may be applied to an integrated device similar to today's existing cellular telephones and personal digital assistants. Furthermore, it is envisioned that the present invention may also apply to the conversion and transmission of analog data (e.g., voice) as well as digital data.

<u>ISP Station Equipment</u>

FIG MM-4 shows the base station configuration. The base station 109 has a GPS antenna 113, a GPS unit 112, RF unit 111 and a computer motherboard 110. The base GPS "Global Positioning Satellite Receiver" 112 and 113 are used to allow base stations to have a common timing reference.

FIG. MM-1 shows the configuration of three cells, cell #1, cell #2 and cell #3, which all use GPS "Global Positioning Satellite" 100 to establish a common reference between the three base stations so at time t1 from the satellite cell #1 uses frequency F1 and cell #2 uses frequency F2 and cell #3 uses frequency F3, at time t2 from the satellite the frequencies are reshuffled as shown in table #1 of FIG. MM-1, and so on.

FIG. MM-5 shows a satellite time frequency plan for the three base stations. This features allows our base stations to reuse frequencies in adjacent cells and further improve the utilization of the frequency spectrum.

In a given cell, such as cell #1 in Fig. MM-1, the modems remain synchronized to the base transmitting station 101 because the base transmitting station 101 transmits a synchronization burst periodically. This synchronization burst helps the modems of cell #1 to follow the carrier hops of the base transmission station 101 in cell #1 because the modems have determined from their programmed firmware which carrier

frequencies the base transmission station 101 will hop to by extracting it from the synchronization burst of the base transmission station 101.

Coded Frequency Spectrum

In the network architecture described above, spread spectrum is employed to allow numerous cells to coexist in the same geographical space.

According to the invention a byte stream acts as codes given to the frequency bank controller to generate a unique spectrum associated with this byte based on a pre defined table of codes relating bytes to spectrums such as shown in Fig. 3.

The output of the frequency bank is then taken to a summing node to create a spectrum. For example, if a three bit byte comes in it will drive the bit0, bit1, bit2 and enable or disable the buffer to create or not to create a sin wave in the spectrum.

In the preferred embodiment, such as shown in Fig. 4, Bit0 to Bit7 are the byte stream input from the computer. Iout is the spectrum output to drive in the phase carrier. Q output is the spectrum output to drive the Q output of the quadrature carrier.

Any transmitter built using coded frequency spectrum modulation in a spread spectrum system, whether frequency hopping of direct sequences for wireless computer communications to create a cellular internet or a wide area network based or not based on cellular internet protocol, falls within the scope of the invention as well as coded frequency spectrum modulation used in wired computer communications whether spread spectrum or not.

Generally, an embodiment of the RF section of the code frequency spectrum modulation receiver is shown in Fig. 5. The antenna receives the signal and amplifies it. Then any out of band signal is filtered out and then mixed with hopping spread spectrum frequencies determined by a synthesizer, which exactly match the same order of the transmitter to generate IF output.

The demodulator stage is shown in Fig. 6. Additional stages of gain are needed to compensate for losses. The I/Q demod demodulates the IF into two spectrums, I code frequency spectrum modulation spectrum and Q code frequency modulation spectrum, respectively. The tone decoding phase locked loops decode the tone components of the code frequency spectrum modulation spectrums into original bits forming the bytes that originally generate the tones; then it is sent to the computer.